Spectrum

A burning issue: decarbonising the global steel industry

Anna Chong
Senior Credit Analyst

Andy Jones
Engagement Professional

Sandy Pei, CFA
Deputy Portfolio Manager, Asia ex-Japan

Sonya Likhtman
Engagement Professional

Stephen Martin
Director, Global Small & Mid Cap

Q2 2021

Federated Hermes International

Steel is essential in today's world, and it will be just as essential tomorrow – much of the technology to create a zero-carbon future, from wind turbines to mass transportation, will use steel in its construction. Yet steel production itself is a highly carbon intensive activity.

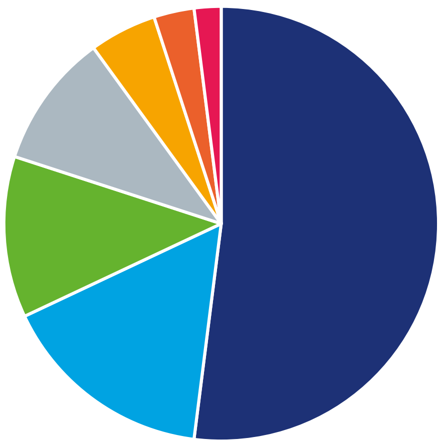
In this issue of *Spectrum*, we look at the available options for steelmakers to decarbonise throughout their value chains and examine the issues around achieving a zero-carbon future for the industry.

Key points

- Steelmaking is a highly polluting process which contributes to up to 10% of global carbon emissions
- However, steel's availability, versatility and recyclability will make it integral to a net-zero future
- Multiple factors make the decarbonisation of steel production a genuine challenge
- With no silver bullet available, a range of short- and long-term solutions will be required

One of the most ubiquitous materials in the modern world, steel is used in everything from suspension bridges and skyscrapers to surgical scalpels and cookware. The ready availability of the iron ore from which steel is made and the immense versatility of the finished material have made it integral to the way we live today.

Figure 1: End markets for steel as of 2019



Source: Federated Hermes, based on data from the World Steel Association, as at April 2020.

Unlike that other great invention of the industrial age, the internal combustion engine, steel looks set to continue its dominance as we transition to a green future: just about every greenhouse gas mitigation technology requires the use of steel, including electrification, thermal energy, and the hydrogen economy.

However, producing steel is itself a carbon intensive activity which is responsible for around 7% of energy sector CO_2 emissions – or closer to 10% if you include the impacts of mining and transporting the required raw materials (it also accounts for 8% of final energy demand).[1] Not only that, but the steel industry is a hard to abate sector for which there is no silver bullet currently on offer.

However, despite the difficulties involved, cleaning up steelmaking will be critical to the wider success of decarbonisation efforts, a fact that governments globally increasingly recognise. Approximately 74% of steel production comes from countries which have a net-zero target in either existing or draft legislation or policy documents, and that figure is only likely to increase.[2] Steel companies therefore face a race to decarbonise before policy changes potentially make their businesses unviable. It is perhaps unsurprising, then, that in recent months four of the top five steel producers have announced intentions to reach net-zero carbon emissions.

How steel is made

Steel is an alloy of iron with a small quantity (less than 2%) of carbon. Depending on the type of steel it can also contain up to 1% of other elements, including manganese, silicon, phosphorus, sulphur and oxygen.

Steel is produced through one of two distinct main processes. The dominant basic oxygen furnace (BOF) process is used in around 72% of global steel production[3]: coal is burned to heat iron ore in a blast furnace, with the coal also acting as a reductant to remove the oxygen from the ore (which is essentially iron oxide).

[1] "Iron and Steel Technology Roadmap," published by the IEA in October 2020.

[2] This is calculated by the international business of Federated Hermes using World Steel Association data from 2020 production by country: https://www.worldsteel.org/en/dam/jcr:2c63e7db-41b9-4441-b7b6-d702f02efbf2/December%25202020%2520crude%2520steel%2520production.pdf and Net Zero Tracker | Energy & Climate Intelligence Unit (eciu.net).

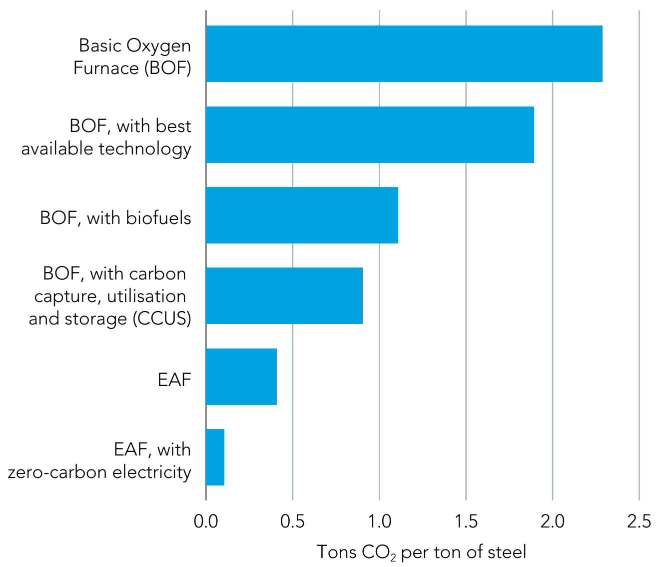
[3] World Steel Association.

The alternative electric arc furnace (EAF) method uses electricity to melt recycled steel, although some quantities of direct reduced iron (DRI) can also be used. This method is estimated to use eight times less energy than the BOF process.

Relative carbon intensity of the two methods

Carbon emissions are a direct by-product of the BOF process, as carbon binds to the oxygen to create carbon dioxide and carbon monoxide. By comparison, the EAF method produces relatively low direct carbon emissions since no coal is required to be used in the furnace itself. To effectively decarbonise the EAF process, two main sources of emissions need to be tackled: (i) the electricity source must be decarbonised and (ii) the DRI must also be produced in a low carbon way.

Figure 2: Relative carbon emission intensity of steel production methods



Source: Materials Economics, BloombergNEF, as at February 2021.

Limitations of electric arc furnaces

Unfortunately, there are significant hurdles to switching production to EAFs. Although steel is one of the most recycled materials in use, the long lifecycle of steel products creates a lag of anything from 20 to 50 years from initial use to availability as scrap. As economies mature steel consumption tends to level off, so that scrap supply can theoretically be sufficient to meet the demand for new steel. However, the lag means scrap availability is based on historical steel use: with global demand for steel growing, particularly in high-growth emerging markets, it currently outstrips supply. This is expected to remain the case well past 2050, when the two-degree scenario in the Paris Agreement should be reached.[4] DRI is also in limited supply and can currently only be made with high quality iron ore, so making up the shortfall using DRI is not a feasible alternative.

Ongoing use of basic oxygen furnaces

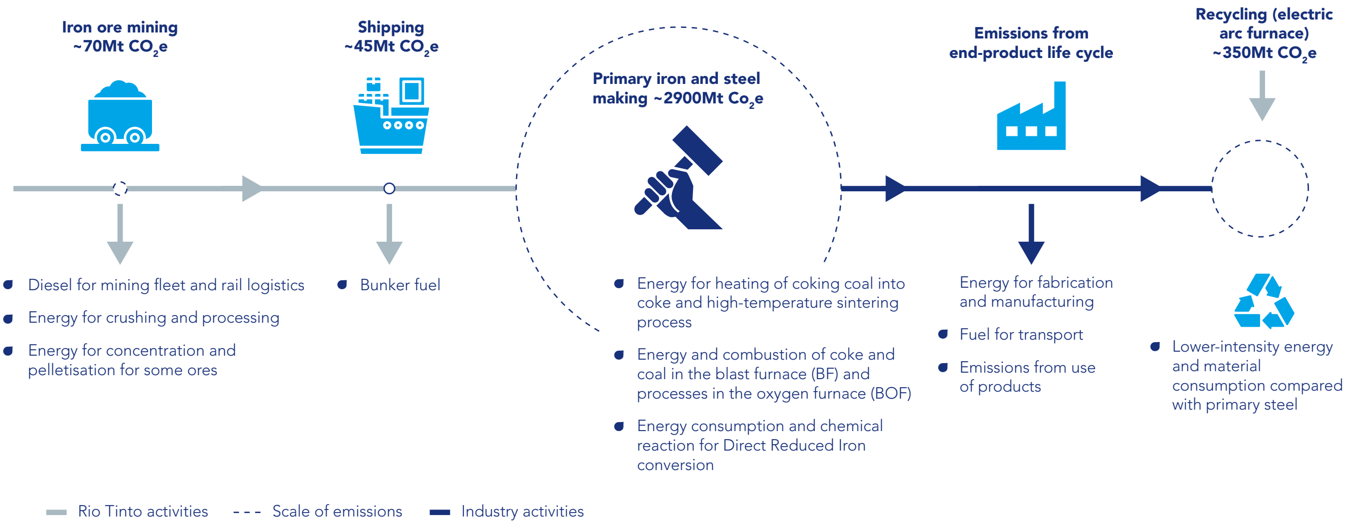
Lack of available scrap and DRI feedstock is one factor that has led to a large fleet of BOFs being built in Asia over the last 20 years. These young furnaces were capital intensive to build and have been used for less than a third of the typical lifespan of such facilities.[5] As the two processes are completely different, there is no potential to convert these blast furnaces into EAFs. Mitigating BOF carbon emissions will therefore be an important intermediate step to meeting decarbonisation goals until such time as wider EAF adoption may become possible.

The steel value chain

The steel value chain starts with the mining of iron ore and metallurgical coal, which is then transported to the site of steel production. Once the raw steel has been made it is usually taken elsewhere to be used in manufacturing and finally distributed as an end product. A high percentage of steel is eventually recycled back into the value chain at the point of steel production as scrap.

[4] https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement
[5] https://www.iea.org/reports/iron-and-steel-technology-roadmap

Figure 3: Emissions throughout the steel value chain



Source: Rio Tinto Climate Change Report, as at 2019.

Relative scale of emissions along the value chain

For steelmaking, the vast majority of emissions are direct emissions from steel production and indirect emissions from electricity use (Scope 1 and Scope 2 respectively). These are the 'Scope 3' emissions of the mining companies that provide the input materials and which increasingly recognise the need to support the reduction of 'downstream' emissions from their customers - especially as these emissions dwarf their own, not insubstantial, Scope 1 and 2 emissions. Figure 3, wherein the circles represent the scale of emissions, illustrates this.

Collaboration to reduce emissions across the value chain

Through our stewardship services team, EOS at Federated Hermes, we engage with companies across the steel value chain on decarbonisation, including mining companies, steel producers and their customers, in particular automotive and construction.

We engage with mining companies on reducing their own Scope 1 and 2 emissions through two main approaches:

1. Reducing Scope 1 emissions through the transitioning of dig, haul and rail fleets from diesel to electric, hydrogen and fuel cell electric vehicles (EVs) – for the most part this is a longer term ambition, although mining EVs including huge dumper trucks are being piloted.
2. Reducing Scope 2 emissions by switching from natural gas and coal to renewable energy sources (especially solar) – this creates net savings and is particularly attractive in the short term.

We also expect mining companies to support the reduction of their Scope 3 emissions, a large proportion of which arise from the use of iron ore and metallurgical coal in steel production. This is particularly important for mining companies as the scale and nature of these emissions creates a high exposure to transition risk through their customers.

Partnerships between mining companies and their steelmaking customers are starting to emerge to address this issue. According to Vale, it seeks to achieve its 15% Scope 3 emissions reduction target by 2035 "through active engagement with clients from the steel and metallurgy industries".[6] Meanwhile, Rio Tinto has announced partnerships with Chinese and Japanese steelmaking customers and incorporated progress on these as a factor in the remuneration of its executives. Over the coming years we will be looking for far greater clarity on the actions and investment of resource taken by each entity along the chain.

Automotive and construction companies are increasingly committing to overall net-zero targets for which they will either need to source zero-carbon steel or seek out alternative zero-carbon materials. Initiatives such as SteelZero[7], which was launched in December 2020, seek to bring together customers of steel companies to drive the demand for zero-carbon steel.

[6] Vale, climate change.
[7] The Climate Group, Steel Zero.

Our expectations of steel companies regarding emissions reduction

As investors, the international business of Federated Hermes has clear criteria for how we expect steelmakers to address emissions reduction:

1) **Net-zero emissions by 2050 at the latest:** Several companies including ArcelorMittal, Baowu Steel, and POSCO have recently made this commitment.

2) **Supporting short and medium-term targets:** Once the long-term goal is in place, short- and medium-term targets should be set, aligning with Paris Agreement goals along the journey to net zero.

3) **Strategy for how these goals will be met:** Targets should be supported by a clear strategy for decarbonisation which indicates the technologies the company will rely on to decarbonise.

4) **CapEx and R&D spend aligned to the goals of the Paris Agreement:** These should be reflective of the chosen strategy and demonstrate the company's contribution to the commercialisation of key technologies.

5) **Strong governance and aligned executive remuneration:** We expect strong oversight from board directors with the skills and experience to hold management to account for delivering on long-term climate strategy; executive pay should be tied to successful climate strategy delivery.

6) **Reporting in line with TCFD* recommendations, including scenario analysis:** Financial reporting and underlying risk management processes should be aligned with the four TCFD pillars; scenario analysis should be used to test the viability and resilience of business models under regulatory and market changes including an EU Border Carbon Adjustment Mechanism and a 1.5°C scenario.

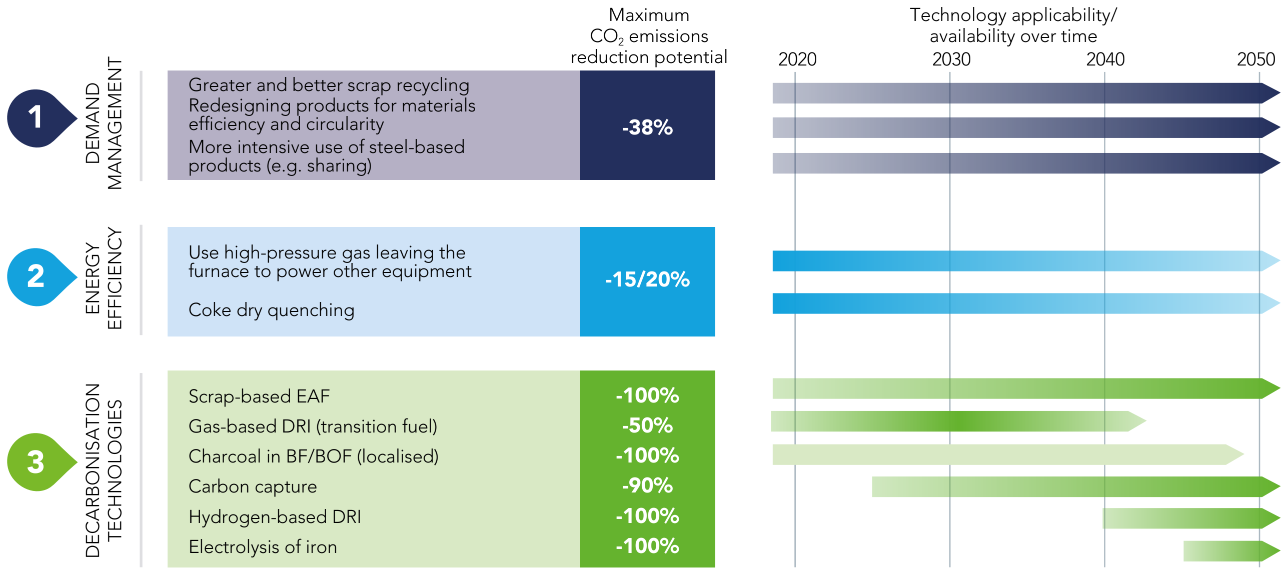
7) **Paris-aligned lobbying and policy advocacy activity:** Companies should ensure lobbying and public policy activities are aligned to Paris Agreement goals, including withdrawing from industry associations where views do not align.

*Task Force on Climate-related Financial Disclosures.

The three routes to decarbonisation

In theory reaching net-zero carbon dioxide emission from steel is possible by combining three main routes: demand management, energy efficiency measures, and decarbonisation technologies.[8] As previously mentioned, none of these represent a magic bullet so it makes sense for the industry to pursue all of these solutions in view of the scale of the task.

Figure 4: The three major decarbonisation routes for the steel industry



Source: Energy Transition Commission.

[8] Energy Transition Commission.

1 Demand management

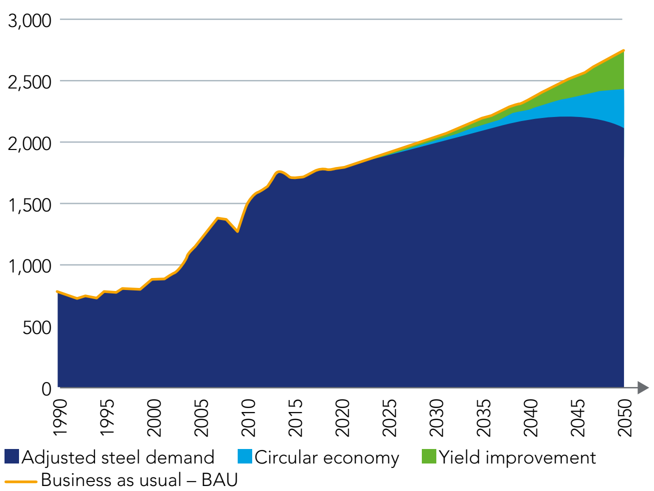
Demand for steel increased sharply from the turn of the millennium through to around 2015 (with a slight dip during the financial crisis of 2008-9). Since then demand has continued to grow, albeit at a slower pace.

As already noted, virtually every technology intended to take us towards a zero-carbon future requires the use of steel – the rise of EVs will have some impact on reducing the use of steel in the auto industry but overall strong demand from developed countries is likely to continue well into the future. At the same time, industrialisation and urbanisation in developing countries will provide a strong new source of demand: India in particular is expected to account for around 40% of incremental steel demand between 2018 and 2050.

In theory, a fully circular economy for steel is possible in which new steel is only made from scrap. However, this can only work if scrap supply meets ongoing demand for new steel. While Chinese demand is reaching a peak, per-capita consumption in other developing countries with large populations (not least India) is still relatively very small. These markets are likely to need huge amounts of steel for future infrastructure development, so global demand may not hit a peak for many years yet. Even when it does, there will be several decades of lag before scrap supply catches up with demand. Until then it will be necessary to produce new steel from ore to fill the gap.

In the longer term new materials and construction techniques may reduce the need for steel. However, even in the best case scenario in terms of demand management, global demand is likely to continue to rise well into the next decade, as you can see from Figure 5.

Figure 5: Future steel demand outlook under different scenarios



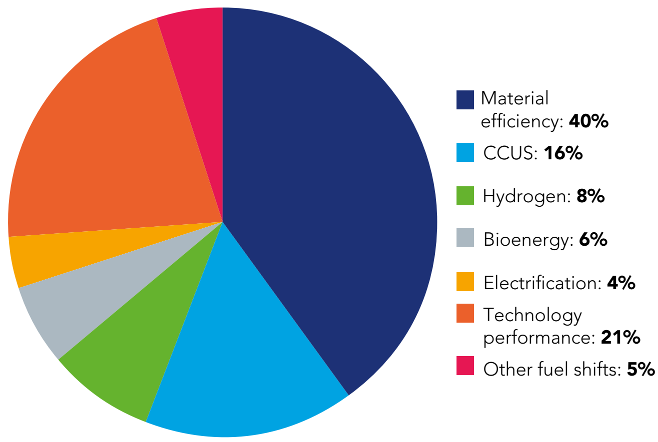
Source: ArcelorMittal Climate Action Report, as at May 2019.

2 Efficiency measures

Improving material efficiency in steelmaking could include increasing yield in the steel manufacturing process and encouraging better customer resource efficiency. Under their Sustainable Development Scenario, the International Energy Agency (IEA) estimates such measures to be able to provide around a 40% reduction in emissions.

One measure which might seem immediately applicable is operational efficiency and reducing the gap between inefficient equipment and best available technologies and processes. This has the potential to offer a further ~20% reduction in emissions according to the IEA.

Figure 6: Cumulative direct emission reductions by mitigation strategy



Source: IEA, as at October 2020.

It is also important to bear in mind the scale of the industry and its energy needs: if all electric arc furnaces in current operation were fully powered by electricity from renewable sources, this would reserve about 40% of existing global wind and solar generating capacity. While renewable energy generating capacity is set to increase, the number of electric arc furnaces in existence will also need to increase significantly if the number of more polluting blast furnaces is to be reduced. Otherwise the much larger source of CO_2 emissions, the reduction of iron ore in blast furnaces, would remain.

3 Technological solutions

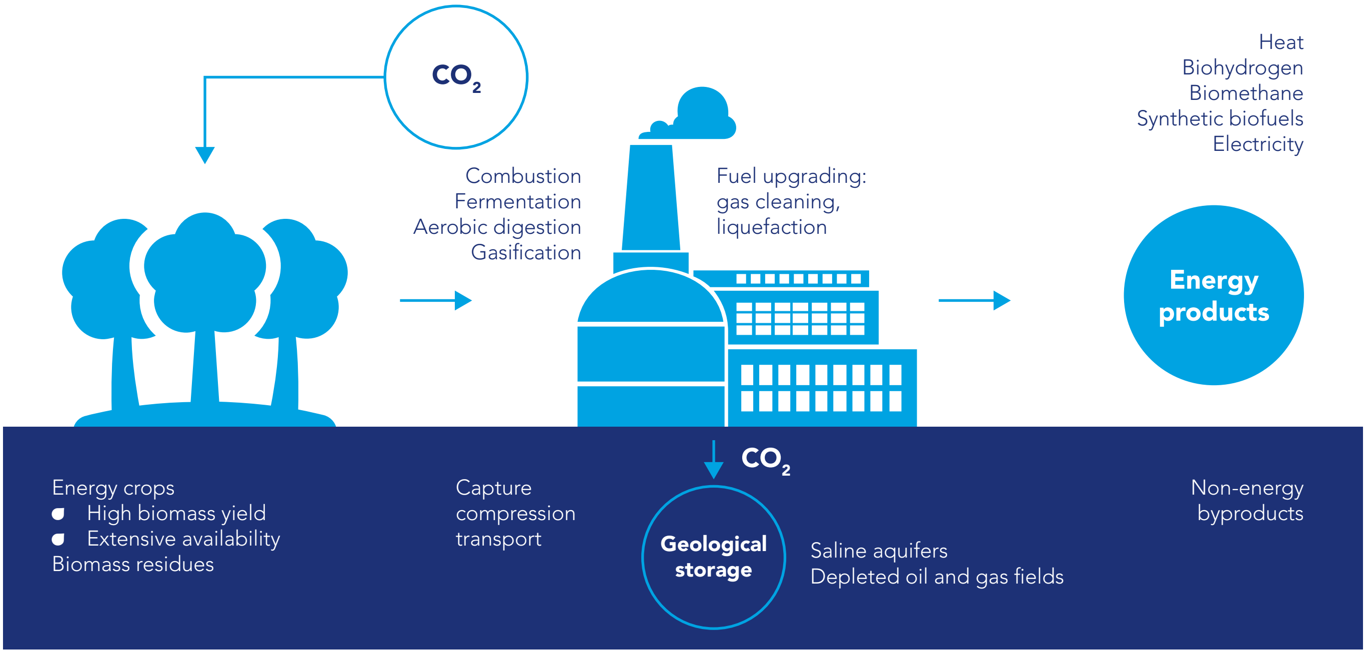
There are a wide range of technological solutions which together could contribute significantly to decarbonising steel production. However, there is likely to be considerable competition with other industries for the resources required for some. Others are too expensive at present to be viable unless governments incentivise the production of 'clean steel' or until further technological progress brings down costs. Given the large global fleet of blast furnaces, technological solutions which can be implemented within the BOF process will be key to the near-term decarbonisation challenge.

Carbon capture, utilisation and storage

Unlike other emitters such as aviation, the steel industry is geographically concentrated in a few large sites. In theory this makes it quite viable to capture carbon emissions from steelmaking at source, both from the blast stoves and from fossil-fuelled onsite power plants. The captured carbon can then either be stored or utilised in other carbon-intensive processes including the production of plastics, fuel, fabrics and chemicals. This route has the advantage of the ability to be used in conjunction with other decarbonisation methods within the BOF processes itself.

At its most basic level, carbon capture and storage involves the planting of a sufficient number of new trees to absorb the CO_2 released by an industry – so-called terrestrial sequestration. However, given the scale of the industry and the finite supply of plantation land this is not a viable option to address more than a small fraction of the emissions from steelmaking.

Figure 7: Carbon capture, utilisation and storage



Source: Royal Society of Chemistry, as at March 2018.

While it might sound outlandish, one short-to-medium term option is to store captured CO_2 underground. CO_2 is already injected underground to force oil and gas to the surface, as part of the process known as direct oil recovery. The US Geological Survey has estimated that storage capacity in depleted US reservoirs alone is equivalent to about 30 years of steel emissions. These rock formations have trapped gas for hundreds of millions of years, so once injected, it should stay put. Where no suitable reservoirs are available it may also be possible to inject CO_2 into saline sub-surface layers. These are much more common, but their gas retention qualities are unproven: the only working project is offshore in Norway and stores CO_2 which has been separated from natural gas in the production of hydrogen.

In terms of utilisation, CO_2 is an essentially inert gas with little use as a fuel. It also takes a lot of energy to break it down, although research is going into how to do this more efficiently, as well as how released carbon could be used – for instance as a structural or conductive material. These are still far from commercialisation, and the question would remain of how to handle derived products at the end of their lives. Another proposed use of captured gas is as a growth medium for algae or euglena which can be converted into biofuels. Again, while promising trials have attracted interest, this technology is a considerable distance from commercialisation, let alone reaching the scale to use significant amounts of captured CO_2. Overall, carbon reuse and storage will need to be incentivised to encourage widespread adoption, but it may simply be more desirable to prevent the CO_2 from being released in the first place.

Replacing fossil fuels as a reductant

To prevent CO_2 being emitted as part of steel production, fossil fuels need to be eliminated from the process. As previously explained, this is not easy to achieve in blast furnaces since the coal used performs a dual role both as a fuel and as a reductant. However, there are options to at least partially replace coal with a fossil-free reductant:

1. **Hydrogen injection in blast furnace:** Hydrogen combines with the oxygen in the iron ore to create harmless water, however, the reaction cools the furnace so hydrogen cannot completely replace coal in the process; resulting emissions reductions are estimated at 20%, but to work even as a short-term decarbonisation pathway green hydrogen would need to be available at scale near blast furnaces.

2. **Hydrogen to produce DRI:** Many DRI facilities use natural gas but are designed to be able to switch to hydrogen once cheaper feedstock is commercially available: it has been estimated that using hydrogen increases production costs by 20-30%[9]; DRI production requires high-quality iron ore which is currently in short supply. However, it is worth noting that commercially produced 'grey' hydrogen is currently derived from fossil fuels (either natural gas or coal) and so, it would reduce CO_2 emissions rather than eliminate them completely. Truly green hydrogen produced by the electrolysis of water into hydrogen and oxygen using electricity from renewable sources would help produce close to zero-carbon steel. Producing the required DRI using such green hydrogen requires a significant scaling up of green hydrogen production and a large increase in renewable electricity capacity. DRI produced using green hydrogen would be processed into steel in electric arc furnaces powered by renewables, making blast furnaces, and the accumulated investment in them, redundant.

3. **Sustainable biomass:** Biomass is already used in Brazil to replace coal in blast furnaces; however, key steelmaking regions such as Germany and China will struggle to access sufficient sustainable biomass as a feedstock, particularly given demand from other carbon-intensive industries for biomass, so this is a less likely route for wide-scale adoption.

4. **Electrolysis of iron ore:** In theory electricity can be used to separate the iron from the oxygen in iron ore through electrolysis, although so far this technology has only been demonstrated in the laboratory; inert anodes will be required and carbon or other elements will need to be added to the iron to create the desired physical properties; capital expenditure is not estimated to be high but energy requirements will be.

How the Asian market impacts the issue

More than 70% of global steelmaking capacity is in Asia, of which around 50% is in China.[10] The Chinese steel industry is a marginal cost producer: the reason the world can enjoy very low cost steel is because China is willing to sell it at a very low price. What happens in Asia is therefore likely to be decisive in terms of when and whether the global steel industry achieves a zero-carbon future.

Structure and nature of the Chinese steel industry

The overall structure of the steel industry in China is very fragmented, with the top producer, Baowu Group, enjoying less than 10% market share (by comparison Posco enjoys 50% market share in South Korea, while Nippon Steel accounts for 40% of Japanese production). As a young industry Chinese steel has yet to be consolidated and that will be a long process.

Globally, around 72% of steel production comes from blast furnaces, with the rest being produced by electric arc furnaces. In China, however, blast furnaces account for nearly 90% of production. This situation is unlikely to change anytime soon for several reasons.

Firstly, there is a limited supply of the scrap steel required as a feedstock for electric arc furnaces: industrialisation is still a relatively recent phenomenon in China, so the buildings, infrastructure and machinery which would provide a ready source of scrap have yet to reach the end of their lifespans. As well as being the world's largest producer, China is also easily the biggest market for steel in the world. Absolute demand is finally levelling off, but scrap generated for steelmaking by demolition and recycling is still ,only about 20% of current needs, and the proportion is only forecast to rise slowly.

Secondly, the vast majority of these blast furnaces themselves are still in the first half of their lifespan. Given the high capital intensity required in construction and commissioning, steel producers have every reason to want to keep them in operation for as long as possible and little incentive to decommission them.

Thirdly, the high cost of electricity in local markets means electric arc furnaces struggle to compete in terms of cost.

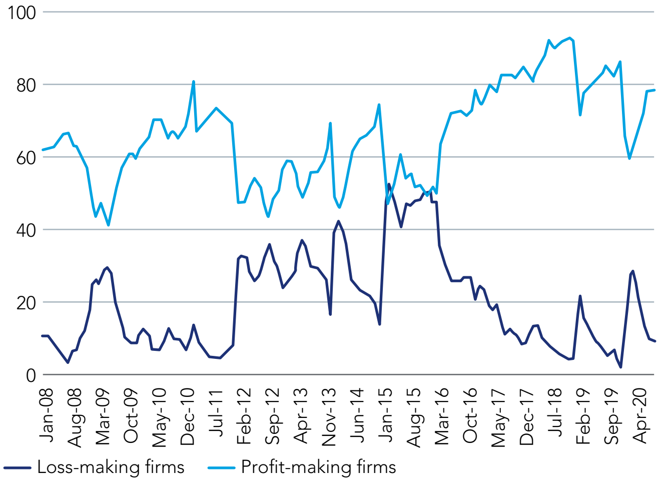
At a loss: financial hurdles to Chinese low carbon steel

Oversupply has meant that Chinese steelmakers have suffered from poor profitability for much of the last ten years. Profitability plummeted as demand growth peaked in 2011, reaching its nadir in 2015 when around 50% of steel producers were making a loss. Supply side reform, including the removal

[9] "Summary of findings from HYBRIT Pre-Feasibility Study 2016–2017," published by SSAB, LKAB and Vattenfall in 2018.
[10] Source: World Steel Association, as at 31 December 2020.

of inefficient capacity, saw the percentage of loss-making companies drop to less than 10% in 2018. This reduced the systematic credit risk of Chinese steelmakers, although the industry remained heavily leveraged. However, the situation worsened again from 2019 due to increased production and the impact on demand of the Covid-19 pandemic, coupled with higher iron ore prices. With supply recently lagging behind demand recovery, steelmakers have been benefiting from a sharp increase in prices since late 2020, however, this is likely to be short-lived as supply picks up.

Figure 8: Percentage of profitable versus unprofitable steelmakers in China over time



Source: CEIC, Daiwa, as at April 2020.

The Chinese government would like to see industry consolidation and progression towards a cleaner China. However, steelmakers are a significant source of employment and a major contributor to GDP (not to mention a source of borrowing for Chinese banks). There are therefore plenty of reasons for the Chinese government to want to see Chinese steel firms survive. As a result, the can is often being kicked down the road, with steelmakers who are effectively zombie companies supported to continue in existence, and efforts towards consolidation and reform slow.

Gearing up for trouble: the problem of leverage

Prolonged low profitability is not the only financial issue for Asian steel companies: high leverage is also a major problem. For example, net gearing for major listed Chinese steelmakers stands at 75%. Average five year returns on assets (ROA) are 3.5%, which is already low enough, yet this masks the fact that for some producers ROA is below 1%. Meanwhile, Korean steelmakers, a major victim of low-priced Chinese steel exports, are in an even more challenging position: markets are giving them a price-to-book ratio as low as 0.2-0.3, based on the belief that their structural return on equity can never recover to higher than 5-6%. This means that Asian steelmakers are effectively unable to raise capital from equity markets and can only deleverage through the organic free cashflow which might be achieved through capital discipline and improved profitability. Capital markets see no solution for the Asian steel industry, which, while not dying is unlikely ever to be truly healthy.

Conclusion

As things stand, the Asian steel industry is unable to afford the kind of capital investment which the transition to a zero-carbon future demands. Structural industry profitability can only improve when the oversupply issue is resolved, but with governments incentivised to support steelmakers, consolidation and reform is likely to be slow to materialise. Significant change in the huge Asian steel sector is therefore unlikely to be driven by the steel producers themselves. It may eventually come as a result of environmentally-driven consolidation and reform, however, that will undoubtedly require steel customers globally to accept higher costs.

For the industry as a whole, demand management, efficiency measures and technological solutions will go a long way to mitigating emissions in the short-to-medium term. However, even using carbon capture, utilisation and storage in conjunction with these methods is not expected to eliminate all emissions. Achieving the ultimate goal of net-zero steel is likely to require the eventual replacement of blast furnaces with electric arc furnaces, potentially supplemented by the adoption of electrolysis production. Feedstock for these electric arc furnaces will ideally come from scrap, with hydrogen-produced DRI potentially making up any shortfall until scrap supply can meet demand. Decarbonising the steel industry is far from a simple task, but it is an essential one if we are to achieve a zero-carbon future.

Federated Hermes International

Federated Hermes

Federated Hermes is a global leader in active, responsible investing.

Guided by our conviction that responsible investing is the best way to create long-term wealth, we provide specialised capabilities across equity, fixed income and private markets, multi-asset and liquidity management strategies, and world-leading stewardship.

Our goals are to help people invest and retire better, to help clients achieve better risk-adjusted returns, and to contribute to positive outcomes that benefit the wider world.

All activities previously carried out by Hermes now form the international business of Federated Hermes. Our brand has evolved, but we still offer the same distinct investment propositions and pioneering responsible investment and stewardship services for which we are renowned – in addition to important new strategies from the entire group.

Our investment and stewardship capabilities:

- **Active equities:** global and regional
- **Fixed income:** across regions, sectors and the yield curve
- **Liquidity:** solutions driven by four decades of experience
- **Private markets:** real estate, infrastructure, private equity and debt
- **Stewardship:** corporate engagement, proxy voting, policy advocacy

For more information, visit **www.hermes-investment.com** or connect with us on social media:

BD007501 0010669 03/21